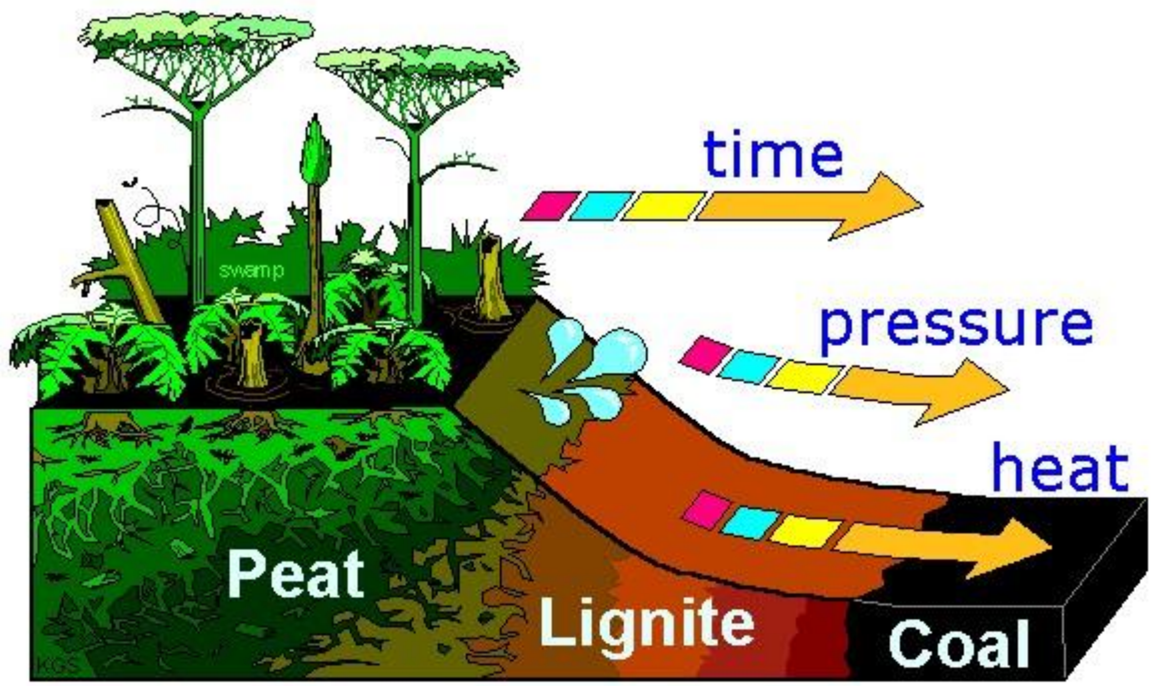
WHAT IS COAL?

The Illinois State Geological Survey (ISGS: www.isgs.uiuc.edu) refers to coal as a "combustible rock" meaning that it will burn when set on fire. They also refer to it as "fossil peat." Peat is partly decayed, moisture-absorbing plant matter found in ancient bogs and swamps. Because peat is only partially decayed, some of the energy of the plants remains trapped in the peat. It is this trapped energy that allows the peat to release heat when it is burned.

FORMATION OF COAL



Organic matter accumulates in bogs or swamps. The matter is covered with water and sediment and only partially decomposes trapping the energy and forming peat. The peat becomes buried under sediment. Geological processes over long periods of time covered, compressed and altered the decaying plants, gradually transforming this material to coal.

Depending on temperature and pressure differences, the resulting coals contain different percentages of carbon and exhibit different degrees of "hardness." No two coals are exactly alike. Heating value, ash melting temperature, sulfur and other impurities, mechanical strength, and many other chemical and physical properties are dependent upon the plant and animal species and the physical and chemical characteristics of the soil and water in the surrounding environment during coal formation.

ILLINOIS COAL

The formation of Illinois coal began during a part of Geologic Time called the Pennsylvanian Period about 300 million years ago. (Refer to the Geologic Time Table) During this period, the area that is now called Illinois was near the equator and had a climate much like that of Indonesia today. Tropical climates promoted lush vegetation growth and the subsequent accumulation of plant debris in widespread swamps.

The plants that flourished in these lush swamp forests were somewhat different from the plants we see in today's forests because deciduous (leaf-bearing) trees and flowering plants did not exist. Giant ancestors of today's mosses, ferns, scouring rushes and conifers (cone-bearing trees) grew in these swampy areas. Thriving in a constant tropical climate, these plants grew too fast to exhibit growth rings like our trees today.

These swamps contained an organic material called peat. This organic material, like other living things, contained carbon. When the sea level rose, this carbon-laden peat was buried by sediments and condensed by compaction. Peat, mud and sand were slowly compacted by overlying layers. Eventually, time, pressure and heat transformed the peat into coal and grains of mud and sand were cemented together to produce shale and sandstones. Layers of rock, such as, sandstone or shale, formed above and below the coal.

Viewing a coal high-wall from the side, you might see alternating layers of sandstone, shale and coal. These alternating layers are a record of different environments due to changes in sea level.

The amount of sulfur in coal seems to be related to the kind of rock layers that lie immediately above the coal seam. Coal seams lying under ocean sediments of limestone and black shale consistently contain more than 2.5 percent sulfur. Coal seams beneath gray shale and siltstone that formed in and along major streams and rivers contain less sulfur. Most Illinois coal was formed under ocean sediments and therefore has a relatively high sulfur content.

The sulfur in Illinois coal occurs principally in two forms: as the iron sulfide mineral called pyrite, and as organic sulfur that was present in the original, coal-forming plants that lived about 300 million years ago. Pyrite can be easily removed from the coal by washing the coal and using a float-and-sink separation method. Organic sulfur cannot be removed in the washing process. However, devices called “scrubbers” can remove the sulfur in the flue gas after combustion.

MISCELLANEOUS COAL FACTS

Lignite coal is the lowest ranked coal, characterized by high moisture; this is a geologically young coal and tends to crumble when shipped long distances.

Bituminous coal is the most common coal found in the U.S. Of all the states, Illinois has the largest reported bituminous coal resources.

Different layers are visible in bituminous coal:

> Vitrain, or wood material that was preserved, forms a bright, glassy, brittle layer;
>
> Clarain, formed from fine plant debris, with a bright, brittle and satiny texture
>
> Fusain, made from chemically changed wood, with a dull black, charcoal-like appearance

Anthracite is deep black and looks metallic because it is very glossy and shiny. It has the highest carbon content and low volatile matter that burns with a clean flame.FOUR

TYPES OF COAL

Coals exhibit a wide range of properties due to:

- the differences in plant materials and mineral matter (i.e. clays, calcite, pyrite and silica)
- the amount of decay of plant materials achieved before burial, and
- the degree of physical and chemical alteration after burial.

Coal Table

Rank	**Color/Luster**	**Texture/ Hardness**	**Plant Remains**	**Cleavage**	**Heat Value in Btu's % of Carbon**
Lignite (brown coal)	Dull brownish-black with irregular layers	Powdery, soft	May be present	Crumbles	4,000 to 8,300 Btu's 25% - 35%
Subbituminous	Dull black	Moderate to hard	None	Uneven	8,300 to 11,500 Btu's 35% - 45%
Bituminous (soft coal)	Smooth, shiny black with visible layers	Breaks easily with a hammer	None	Uneven	10,500 to 15,500 Btu's 45% - 86%
Anthracite (hard coal)	Bright black-gray color, glossy, metallic	Hard	None	Uneven to glass-like	15,000 Btu's 86% - 97%

Rank	**Location**	**Availability**	**Uses**
Lignite	Gulf Coast & Northern Plains	About 9% of US coal reserves	Generating electricity
Subbituminous	Western U.S. (MT, WY, CO, NM, AK)	38 % of US coal reserves	Generating electricity
Bituminous	Appalachia & the Midwest Illinois' main coal type	Over 50% of US coal reserves	Generating electricity,; Producing coke for steel industry (not the cola)
Anthracite	Northeastern PA & East Coast	About 2% of US coal reserves	Generating electricity; Heating

Geologic Time Line

Era	**Period**	Years Ago (in millions)	Duration (in millions of years)	Length on paper	**Major organisms and events**
zoic	Quaternary	1.6	1.6	1.6 cm.	modern mammals, woolly mammoth, musk ox Great Ice Age
	Tertiary	65	63	6.3 cm.	horses, camels, grasslands, primates, whales rodents; grasslands expand
zoic	Cretaceous	144	79	7.9 cm.	mass extinction; gastropods, dinosaurs domin ice-free poles
	Jurassic	208	65	6.5 cm.	small mammals, first large dinosaurs, first frog toads and salamanders, first bird – Archaeopt reptile-like birds, ferns, cyads, gingkoes, conif
	Triassic	245	40	4.0 cm.	continental rifting, climate warms
ozoic	Permian	286	41	4.1 cm.	modern insects, dragonflies, beetles, palm tre large reptiles; Pangaea
	Pennsylvanian	320	34	3.4 cm.	ferns, horsetails, cockroaches; coal-forming sediments in vast swamps
	Mississippian	360	40	4.0 cm.	crinoids, brachiopods, land reptiles, amphibia glaciation, climate change
	Devonian	408	48	4.8 cm.	spiders, mites, lung fish
	Silurian	438	30	3.0 cm.	leafless plants, first sharks, arthropods
	Ordovician	505	67	6.7 cm.	corals, crinoids, corals, clams, sponges trilobi
	Cambrian	570	65	6.5 cm.	marine algae; super continent
ambrian		4,600	4.03 billion	4.03 m.	stromatalites, worms, jellyfish, algae, single-c organisms

Model

The model will simulate the coal formation process over the course of three days. Teachers may desire for each student to make their own model, or they may wish to make one model for classroom demonstration.

Materials

-Clay
-Soil
-Dried leaf & grass clippings
-Sand
-Disposable plastic cups for mixing
-Clear plastic cup or soda bottle for model
-Water
-Elmers glue

Instructions

Day 1

1. Place the sand in a clear plastic cup or soda bottle.
2. Add enough water to make it pourable.
3. Add a couple of squeezes of glue to help create a mixture. The glue represents the cementation that takes place over millions of years.
4. Allow to dry to resemble sandstone.

Day 2

1. Mix soil and dried leaf & grass clippings to a plastic mixing cup.
2. Add enough glue to make the mixture pourable.
3. Pour the mixture on top of the “sandstone” from Day 1.
4. Allow the mixture to dry overnight to simulate the coal layer.

Day 3

1. Place clay in a plastic cup.
2. Add enough water so it will pour.
3. Add a couple of squeezes of glue to help cement the mixture.
4. Pour this over the “coal layer” and allow to dry.

Day 4: Observing the Coal Seam

You have created a layer of coal between two layers of rocks. The bottom part of the cup contains the sandstone. The dark layer represents the coal seam, and the top layer represents the shale that overlie many of Illinois coal seams.

Discussion Questions

1. What happened to the leaves when the layer of clay was added? (They stopped decomposing.)
2. What materials represent deposits (sedimentation) from the sea? (Sand formed sandstone and clay deposits formed shale.).
3. What components are made up of carbon? (All living organisms.)

4. How long would it take for coal to form? (millions of years)
5. Why is coal considered a fossil fuel? (Because the coal contains fossils of dead organisms and the energy in the coal can be used as fuel.)
6. How would engineers determine the quality of the coal layer? (core-sampling, drilling)
7. How could the coal layer be excavated? (surface mining and underground mining)

Extension

Plants: Past & Present

1. How do plants today compare with those living millions of years ago?
2. Refer to Common Pennsylvanian Plants (See Appendix I). Compare pictures of trees or flowering plants that live today to the plants that formed coal.

Construct a Geologic Timeline

1. List significant events while discovering coal's unique niche in the earth's history.
2. Using 1 millimeter = 1 million years, mark the eras and periods using approximately 6 meters of continuous track feed computer paper (or adding machine paper) and the Geologic Timeline information provided. Sketch and label the appropriate organisms that occur for each time period. (See Appendix I)

Simulate Plant Compaction

1. Place a thick, moist sponge in the base of a clear jar and measure the height of the sponge.
2. Add gravel until the sponge is compacted to 1/8 of the original thickness.
3. Imagine the sponge is actually a bunch of dead plants covered by rock. If this sponge were a developing seam of coal, would it provide better fuel at the beginning of this experiment or at the end? Why? How does the presence of moisture impact fuel?